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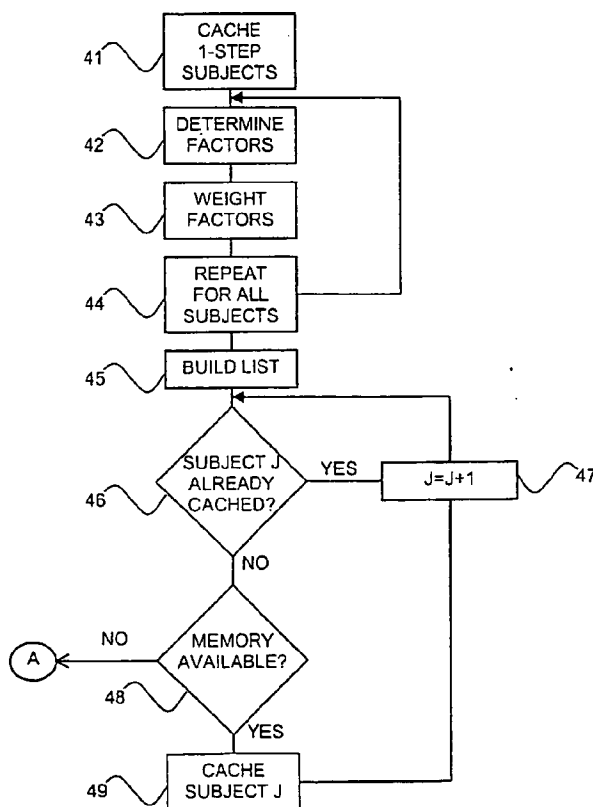
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[Continued on next page]

(54) Title: A METHOD FOR DYNAMIC CACHING



(57) Abstract: The present invention relates to a method for caching media content on a client, comprising organizing media subjects in a predefined media package structure, and downloading said structure to the client in order for a user to consume the subjects in said structure. The media structure is arranged to allow a user to request media subjects by navigating from a current subject to adjacent subjects in the structure, and these adjacent subjects are cached at the client in advance, before the user requests them. By downloading the adjacent media subjects, the user will get the impression that the entire media structure is cached, and will not experience any download delays.



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A METHOD FOR DYNAMIC CACHINGTechnical field

The present invention is related to a method for
5 providing media contents to a user. More specifically,
the present invention is concerned with how to cache data
at a client when consuming media for improving the media
experience when the bandwidth is limited.

10 Technical background

The definition of limited bandwidth depends on the
media. For example, video sent over Internet today has
limitations, while text is practically without limits, as
the download time is usually negligible compared to the
15 time required reading it. Even though the main focus in
this text is on mobile devices like phones or PDAs the
same techniques could be used at higher bandwidths for
other types of media.

There are basically three techniques for caching
20 media content accessed over a data network, e.g. the
Internet, on a handheld device.

1) Package download.

An example of this approach is the AvantGo system,
applicable for example with a Palm Pilot device.

25 The user downloads and stores (caches) a package
comprising several media clips, and then navigates among
these clips. No Internet connection is required during
consumption, as the entire package, with all its media
contents, is downloaded and stored in the handheld
30 device. On the other hand, the media experience will be
limited to the contents of the downloaded package. It is

costly to include extensive media contents, especially if the download is over a mobile communication link.

2) Streaming.

The user receives a continuous stream of media, equivalent to listening to a CD or a radio station. In this case, the client is adapted to download one single media clip, and playback this clip during download.

The simultaneous playback and download is accomplished by caching in the clients memory, and requires an uninterrupted internet connection, preferably a wide band connection. The user has limited ways to control the media experience, at best a one dimensional navigation, i.e. stop, play, back and fast forward.

3) Web browser caching

Although primarily used in stationary clients (workstations), web browsing may be implemented in for example a WAP-telephone or a GPRS-or UMTS-device, connected continuously to a network.

While providing the user with a dynamic media experience, browsing has the drawback that contents are only downloaded and cached when the user request them, leading to disturbing delays. An accessed web page (including media files like pictures) will normally be saved on the client for a specified time in order to speed up future access to the same web page. This does not, however, address the problem of delays when requesting new information.

It is clear from the above that an increased dynamics in the media experience (free browsing) is gained only to the price of a unsatisfactory caching procedure, where the caching is always one step behind the user. On the contrary, access without caching interruptions, e.g. wide band streaming or AvantGo type

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package systems, gives little, if any, dynamics in the media experience. Prior art gives no solution to the problem of providing a satisfying media experience, without regular interruption by caching.

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Objects of the invention

A first object of the invention is to provide a method for caching of media contents, enabling the user
10 to have a satisfying media experience, with a minimum of interruptions.

A further object of the invention is to provide a method for caching of media content minimizing the cost for a satisfying media experience.

15

Summary of the invention

According to the invention, this and other objects are achieved by arranging the media structure to allow a user to request media subjects by navigating from a
20 current subject to adjacent subjects in the structure, and to cache adjacent subjects at the client in advance, before the user requests them.

This "pre-caching" is similar to the caching mentioned above in relation to web browsing, especially
25 when revisiting a site that was recently visited, in which case several "adjacent", i.e. linked, pages are already cached at the client. However, the important difference is that a web browser never tries to predict which links (to other web pages) the user will access and
30 pre-cache these web pages in order to speed up the access to these pages. In fact, in normal, unrestricted web browsing, this would be quite troublesome. The present invention makes use of the fact that the users navigation

within the media structure is restricted to a few directions, thus reducing the number of subjects that need to be cached.

By downloading the adjacent media subjects, the user
5 will get the impression that the entire media structure is cached, and will not experience any download delays, under the condition that the adjacent subjects always can be downloaded during the time the user consumes the current media subject.

10 In an embodiment of the invention, the method further comprises determining, for a subset of subjects in the structure, the following factors:

- distance to the subject from the current subject,
- approximated consumption time of any intermediate
15 subjects between the subject and the current subject,

- download time of the subject,

and, by weighting said factors, prioritizing the subjects in said subset and caching subjects in an order
20 based on this prioritization.

When a user navigates in the media structure, normally configured as a "tree" of pieces of media contents ("subjects"), the users next move is very limited. However, even after two or three moves, the
25 number of reachable points in the tree is large enough to make caching of all these pieces of media contents too time consuming to be efficient. The weighting of the mentioned factors to form a priority order, will provide for a systematic selection process, enabling caching of
30 the "right" media subjects. The factors can also include a prediction of which subjects the user is most likely to navigate to.

The subjects in the subset can be ordered in a list, and the client can cache subjects in this order, to the extent there is cache memory available. In the event of insufficient cache memory, cached subjects outside said
5 subset can be identified and erased from the cache memory. It may be advantageous to erase consumed subjects before unconsumed.

In another embodiment, the method further comprises defining two modes of navigation of the client, a first,
10 continuous navigation mode, characterized by restricted movement between subjects being located adjacent in the structure, and a second, discontinuous mode, characterized by unrestricted movement between subjects, determining which mode of navigation the user is
15 currently using, and basing said prediction on the currently used mode of navigation.

This functionality improves the intelligent caching of subjects, by keeping track of how the user navigates, and letting this information influence the caching
20 procedure.

Brief description of the drawings

These and other aspects of the invention will be apparent from the preferred embodiments more clearly
25 described with reference to the appended drawings.

Fig 1 shows an example of a handheld mobile device, suitable for implementation of the present invention.

Fig 2 shows an example of a magazine structure according to the preferred embodiment of the invention.

30 Fig 3 shows a time line of consumption time vs. download times.

Fig 4 shows a flowchart of a caching procedure according to the preferred embodiment of the invention.

Fig 5 shows a flowchart of a caching out procedure according to the preferred embodiment of the invention.

Detailed description of the currently preferred
5 embodiment

The currently preferred embodiment is related to the concept of Mediabricks'™ magazines. This should not be regarded as a limitation to the scope of the appended claims, but only as an example of a situation where the
10 present invention may be implemented successfully.

The client is assumed to be a handheld mobile communication device with media playback functionality, such as the PDA 1 illustrated in fig 1.

Definitions

15 In this description of the preferred embodiment, a few terms are given a special meaning:

1. Media subject - a piece of media contents, further organized in different layers. Each subject can have audio, video, images, text etc.

20 2. Magazine - a collection of media subjects, organized in a defined media package structure.

3. Current media subject - the subject in the package structure a user is currently consuming (reading, watching, listening to etc).

25 In order to provide a satisfying media experience, the user should be able to consume the subjects in the structure without having to wait for new subjects to be downloaded to the mobile device. As mentioned above, one way to avoid interrupts while consuming the data is to
30 load everything before it is consumed. The approach with Mediabricks'™ magazines is to:

- Be on-line while reading, having access to the latest information

- Initially only load the description (structure) of the magazine
- Only download the subjects that the user wants to consume
- 5 • Load at least a whole subject before consuming, i.e. no streaming media.

The basic idea is to download new subjects to the device while the current subject is consumed. In other words, the download time of additional subjects is
10 restricted to the time a user needs to consume the current media subject. The result is similar to streaming, but with improved flexibility for the user, and the added complexity of not knowing the next subject or the time the user will spend on the current subject.

15 Download time

The time to download a subject consists of:

- Request from client to server
- Time for the server to process the request
- Result from server to client
- 20 • Download time related to the size of the subject and the bandwidth
- Time for the client to cache the result

The time for a request to go to the server and an empty result to go back is not dependent on the size of a
25 subject. Neither is the time needed for the server to process the request given that the server is reasonable fast. The caching time in the client has both a fixed and size dependent part.

Generally the download time can be seen as a fixed
30 time for each subject and a variable time dependent on the size. If the fixed part is a larger than the variable it is better trying to cache several subjects in one

request to decrease the overhead time for each subject. Another thing to consider is that the request and results probably are using a packet based protocol and it is advantageous to fill every packet with data instead of
5 using half the packets. In the following description it is assumed that the size dependent time for a request is a lot longer than the fixed part. When this is not the case, e.g. when using satellite communication with significant initialization times, the described method
10 should be slightly adjusted by the skilled man.

The load on the network or server has an impact on each client. When a mobile user changes carrier, for example from a GPRS connection to a radio LAN, the download times changes too. The mobile device should
15 adjust the expected download time accordingly by keeping statistics from earlier downloads. By simply measuring the download time for the last N downloads (again, assuming that the smaller fixed part is negligible), and relating it to the number of downloaded bytes, an
20 estimated average download rate can be determined:

$$\text{expected bytes/second} = \text{average}(\text{SizeN} / \text{DownloadtimeN})$$

Consumption Time

The consumption time is the time the user is expected to spend at each subject. Depending on the media
25 type it is more or less predictable:

- Audio - given in the file format, for example the length of an mp3-file, provided of course that the user does not fast forward etc.
- Text - related to the length of the text, but also
30 the reading speed for each user. By collecting statistics of the user's reading speed and behavior it should be possible to determine a reasonable estimate.

- Pictures - difficult to estimate. An approximation can be based on user behavior, for example average time spent on each picture when browsing an on-line album with photographs.

5 In reality the expected consumption time will not be exact. A user might jump to another subject before the current one is consumed or the estimation could be wrong. Statistical data can be collected to improve the estimation. Note that the statistics should ignore very
10 short stops, or skips, when the user moves over a subject without consuming it at all.

Navigation mode 1

Navigation in a magazine can be done by using navigation buttons 2 on the PDA 1, intended for this
15 purpose. This type of navigation is referred to as mode 1 navigation. In a typical case, which will be further described below, the PDA has four buttons 2a-d: forward 2a, backward 2b, up 2c and down 2d. When navigating in the magazine with these buttons, the user can only move
20 in these four directions: forward - next subject on the same level, back - previous subject on the same level, down - move to a more detailed level, up - move to a more general level. This is more restricted movement than in a typical web browser, and this restriction facilitates an
25 intelligent dynamic caching. By knowing to what subjects the user can navigate to from the currently consumed subject, it is possible to predict the next subject and download it to the device while the current subject is consumed.

30 It is also possible that the PDA also has an automatic mode, in which the media player automatically continues to the next subject after a subject is consumed. The "next" subject may be defined by a

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predetermined path through the magazine, either decided by the content provider or by user preferences. Automatic mode can be regarded as a special case of mode 1 navigation. The magazines should preferably be
5 constructed so the typical consumer is happy with the predetermined path and only does a few explorations into interesting articles.

To enhance the media experience, subject are cached in the PDA memory 3, and ideally a subject is cached just
10 before the user navigates to it.

Selection process

Fig 2 gives an example of a magazine structure with a currently consumed subject, 0_current 21. As mentioned above, it is possible to move in four directions:
15 forward, backward, up and down. All the subjects that are reachable within two moves are shown in the structure, and are labeled 1_<direction> or 2_<direction1>_<direction2>.

In this example, up is assumed to lead to the
20 "parent" subject 22, i.e. the subject on the closest more general level leading to the current subject 21. Alternatively, up leads to the next subject 23 on the parent level, in which case the user does not need to revisit the subject 22, which has previously been
25 visited.

The back direction normally indicates the previous subject on the same level, but when the first subject on a level is reached, back will lead to the parent. In the figure, this is illustrated by the fact that the parent
30 subject 22 can be reached by pressing back twice (2_back_back).

The only way the current subject 21 (0_current) could have been reached the first time, i.e. not through

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a child level, is through the subject 1_back. Therefore, 1_back is always cached when the user is at 0_current. Further, the only way to reach the subjects on the current level is through the parent subject 22, which
5 means that 1_up is also cached.

From this follows that, if the 1_down and 1_forward subjects are cached for each visited subject, and no subjects are cached out, then the subjects 1_back and 1_up are already cached for any subject that the user may
10 navigate to. In other words it will be enough to cache 1_down and 1_forward, two new subjects, during the time 0_current is consumed. If there is enough time to do this for every subject our goal is achieved, and the user never has to wait for any new subject to be loaded.

15 If the average consumption time is less than twice the average download time the situation is difficult and the device will often be out of data. The magazines should therefore be designed so the average consumption time is larger than the download times. The ratio between
20 the average consumption time and the download time can be used as a measurement of how good a magazine is for caching.

There will be errors both in the estimated consumption time and in the download times. A special
25 case of consumption time error is when the user chooses not to consume a subject, but moves on directly (zapping). When such deviations from the estimations occur, it is possible that a subject that is not in the cache will be reached. By trying to cache the subjects
30 more than one step from current subject the risk is decreased. The time to load these subjects is the remaining time after 1_down and 1_forward has been cached (see fig 3), ie:

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consumption time (0_current) - download time
(1_forward) - download time (1_down).

If the caching is extended to two steps away from the current subject, 6 subjects can be reached in the structure in fig 2. (Not counting 2_back_back which is equal to 1_up). Even if the client memory 3 were sufficient to cache all these subjects, the consumption time of the present subject might be too short for this. Therefore, an intelligent selection process is required, which is implemented in the PDA as a software 4 controlling the processor 5 and communication interface 6. If the client memory 3 is insufficient, this requirement is even more evident.

Note that such a selection process not should be limited to subjects two steps away from the current subject. Rather, the selection should be made unbiased to all factors, in order to accomplish a dynamic caching of subjects resulting in a satisfying media experience. It might be the case that a 3-step subject is selected before a 2-step subject, if the circumstances are such.

Different selection criteria can be identified for determining which subjects to cache:

Steps to the subject

Naturally, as mentioned above, the subjects immediately next to the currently consumed subject should always be cached. After that, the priority is roughly inversely proportional to the distance from the current subject.

Time to consumption

By adding all the consumption times for all the subjects on the path to a subject, the estimated time before that subject is needed can be computed. It can be realized that a subject that is "hidden" behind a closer

subject with a long consumption time, can be given a low caching priority. It can instead be cached while this closer subject is being consumed.

Download time

5 If the download time for a certain subject is long it might be better to chose another subject which will be loaded in time and hope that the user chooses that path. The same reasoning could be applied to a string of related subjects.

10 *Consumption patterns*

For certain packages the consumer might follow a similar path each time. This path should be remembered by the device by keeping statistics for each subscribed magazine, so that this path can be prioritized. Some
15 users might want to consume all subjects on a particular path before moving on to a different path.

Preferences

Variables influencing the consumption may be defined by the user or the media content provider. Tagging by the
20 media subjects may be used to enable the user to prioritize certain types of subjects.

Links

A subject may relate to another subject, possibly in a different magazine, and that a direct link can be built
25 into the structure.

Each criteria should have a weight, ie multiplication factor, attached to them. Depending on how the device is used, the weights should adjust to learn the user's behavior. By adding the criteria for each
30 subject can the cache points can be calculated and the subject with the most cache points is the next one to be downloaded.

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With reference to fig 4, a preferred selection process will now be described in further detail.

First, in step 41, all subjects one step away from the current subject are cached. As mentioned above, this
5 normally means maximum two new cached subjects.

In step 42, a number of factors are calculated for a subject, and in step 43, a priority is determined this subject by weighting the different factors:

priority =

10 $W1 \times \text{time to consumption}$
 + $W2 \times \text{time for download}$
 + $W3 \times \text{probability for direct move}$
 + $W4 \times \text{additional factors}.$

The steps 42 and 43 are repeated for all subjects
15 within N steps from the current subject (step 44), and in step 45 the resulting priorities are ordered in a sorted list. The value of N is dependent upon the available processing capacity, and indirectly the available memory. Even if the processor can perform the steps 42 - 45 for
20 all subject within the required time, this will not improve the selection process unless the memory can cache more subjects.

In step 46, it is checked if the subject with index j (the index j starting at the top of the list, with the
25 subject with the highest priority) is already cached. If this is the case, the program control increases j by one (step 47) and returns to step 6 and performs the check for the following subject. However, if the subject is not cached, program control proceeds to step 48, where it is
30 checked if there is enough cache memory available to cache the subject. If this is the case, the subject is cached (step 49), and program control continues to step

15

47, where j is increased, and then returns to step 46 again.

If there is not enough cache memory in step 48, program control proceeds to an cache out routine in steps 50-55 (cache out = erase previously cached subjects from memory). In step 51, it is checked if there are read subjects located at least a predefined distance "behind" the current subject. The direction "behind" is defined in a way so as to corresponding to areas of the structure that have been passed by the user. The distance should be greater than N steps, i.e. only subjects outside the prioritized list are cached out. If read subjects are found, one of these is cached out in step 52, and program control returns to step 48. Otherwise, in step 53, it is checked if there are unread subjects located at least a predefined distance behind the current subject (possibly different from the distance in step 50). If so, one of these subjects is cached out in step 54, and program control returns to step 48. Otherwise, in step 55, the subject at the end of the list is cached out and program control returns to step 48.

It is sometimes advantageous to return all the way to step 42 each time a subject has been cached in or out, as this possibly results in a change in the factors determining the priority order. Alternatively, a control is performed each time a subject is cached in or out, to find out if a return to step 42 is deemed necessary. A third alternative may be to return to step 42 at regular intervals, e.g. every 4 cachings.

According to this procedure, the memory will eventually be filled with the subjects with the highest priority as defined in step 43. However, the process may be interrupted at any time, by the user initiating a

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move. Each time this happens, the program control restarts with step 41.

Navigation mode 2

Returning to fig 1, the PDA 1 intended for use with
5 the Mediabrick™ concept may also have means for direct navigation, in the case shown in fig 1 with the use of a pointing device 7, such as a pen. When the user moves between subjects using such means, the restrictions of the magazine structure are lost, and certain factors
10 mentioned above, such as distance to the current subject, become less important, as the user may suddenly move to any subject available in the structure. Instead, other factors become more important for selecting which subjects should be cached, typically factors related to
15 user behavior.

According to the preferred embodiment, the client is provided with means for determining which navigation mode is being used by the user, and to adapt the caching process to the navigation mode. In fig 1, this is
20 illustrated by a sensor 8, arranged to detect when the pen 7 is removed from the PDA 1.

Upon removal of the pen 7, the weights W1-W4 above are altered in order to increase the importance of e.g. user preferences and consumption patterns. The result is
25 a completely different caching strategy, albeit governed by the same process, outlined in figs 4-5. In certain cases, it might be considered to even cancel the step 41, i.e. to choose not to cache immediately neighboring subjects.

30

CLAIMS

1. Method for caching media content on a client,
comprising organizing media subjects in a predefined
5 media package structure, and downloading said structure
to the client in order for a user to consume the subjects
in said structure, characterized in that the said
media structure is arranged to allow a user to request
media subjects by navigating from a current subject to
10 adjacent subjects in the structure, and in that said
adjacent subjects are cached at the client in advance,
before the user requests them.

2. Method according to claim 1, comprising
15 determining, for a subset of subjects in the structure,
the following factors:

- distance from the current subject,
- approximated consumption time of any intermediate
subjects between the subject and the current
20 subject,
- download time of the subject,

and, by weighting said factors, prioritizing the
subjects in said subset in a list and caching subjects in
an order based on this list.

25 3. Method according to claim 2, further comprising
predicting which subjects the user is most likely to
navigate to, and including this information as a factor
when prioritizing the subjects in said subset.

30 4. Method according to claim 2-3, further
comprising determining if there is sufficient cache

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memory available in the client, and if so caching the next subject in said list.

5. Method according to claim 4, further comprising
5 identifying cached subjects outside said subset, and erasing such subjects from the cache memory.

6. Method according to claim 5, wherein consumed subjects are erased before unconsumed.

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7. Method according to claim 1-6, wherein said subset comprises all subjects located within a certain number (N) steps from the current subject (21).

15 8. Method according to claim 1-7, further comprising

defining two modes of navigation of the client, a first, continuous navigation mode, characterized by restricted movement between subjects being located
20 adjacent in the structure, and a second, discontinuous mode, characterized by unrestricted movement between subjects,

determining which mode of navigation the user is currently using,
25 basing said prediction on the currently used mode of navigation.

9. Method according to any of the preceding claims, wherein the client is a mobile media playback
30 device.

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10. Method according to any of the preceding claims, wherein said structure is a personalized media package structure.

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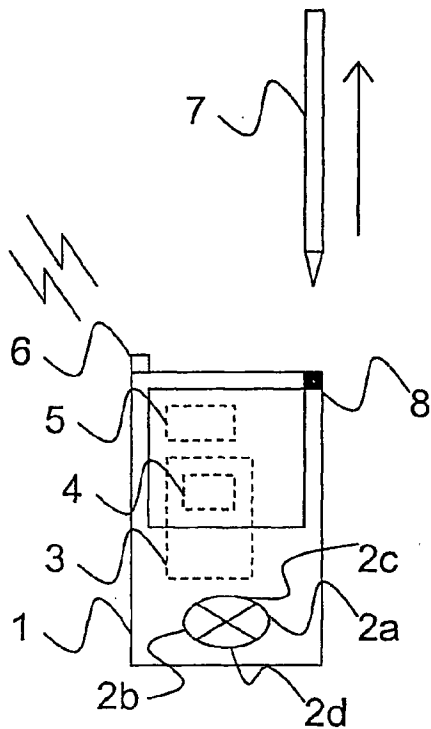


Fig 1

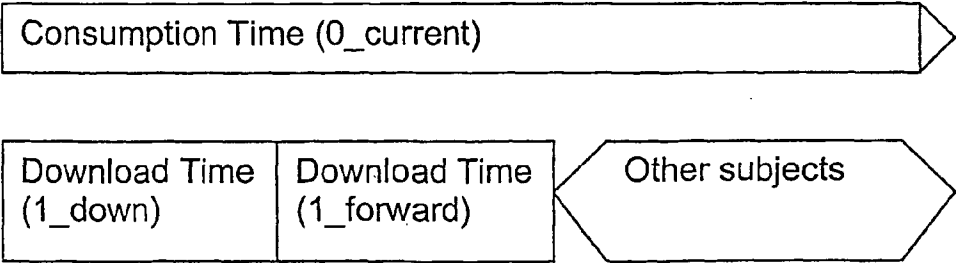


Fig 3

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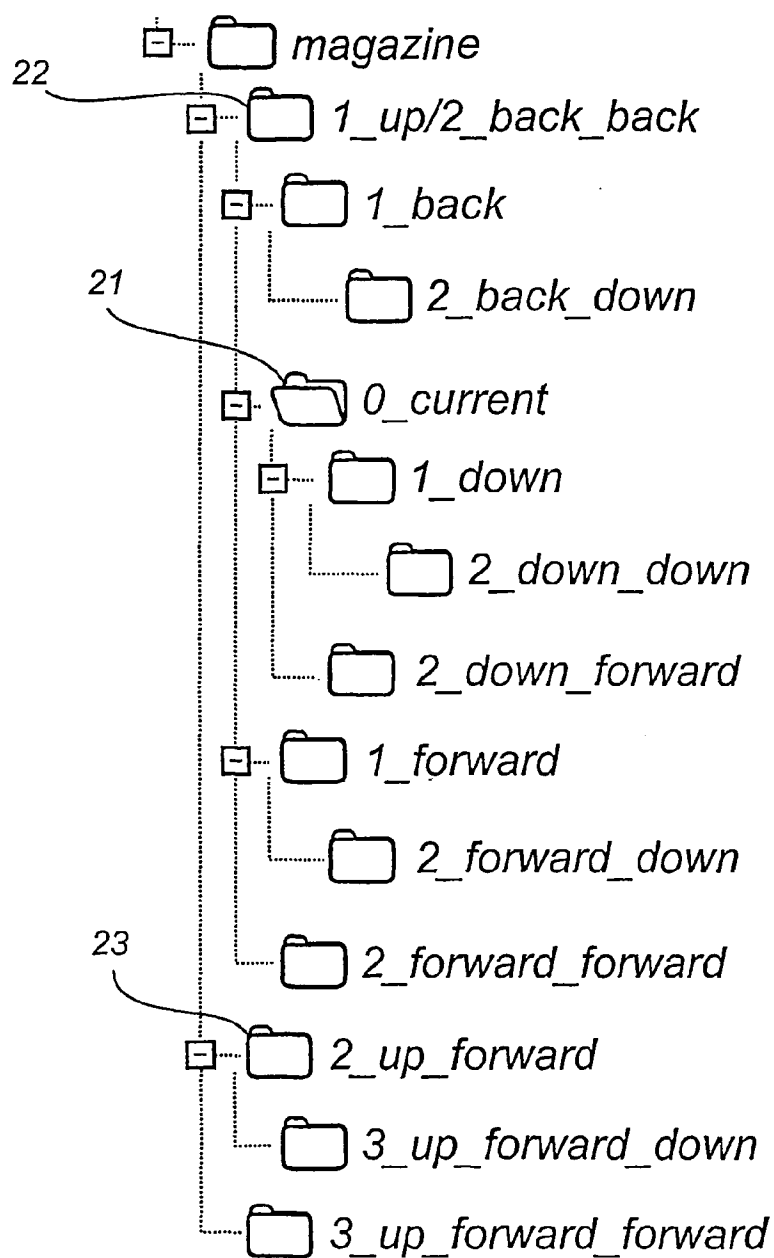


Fig. 2

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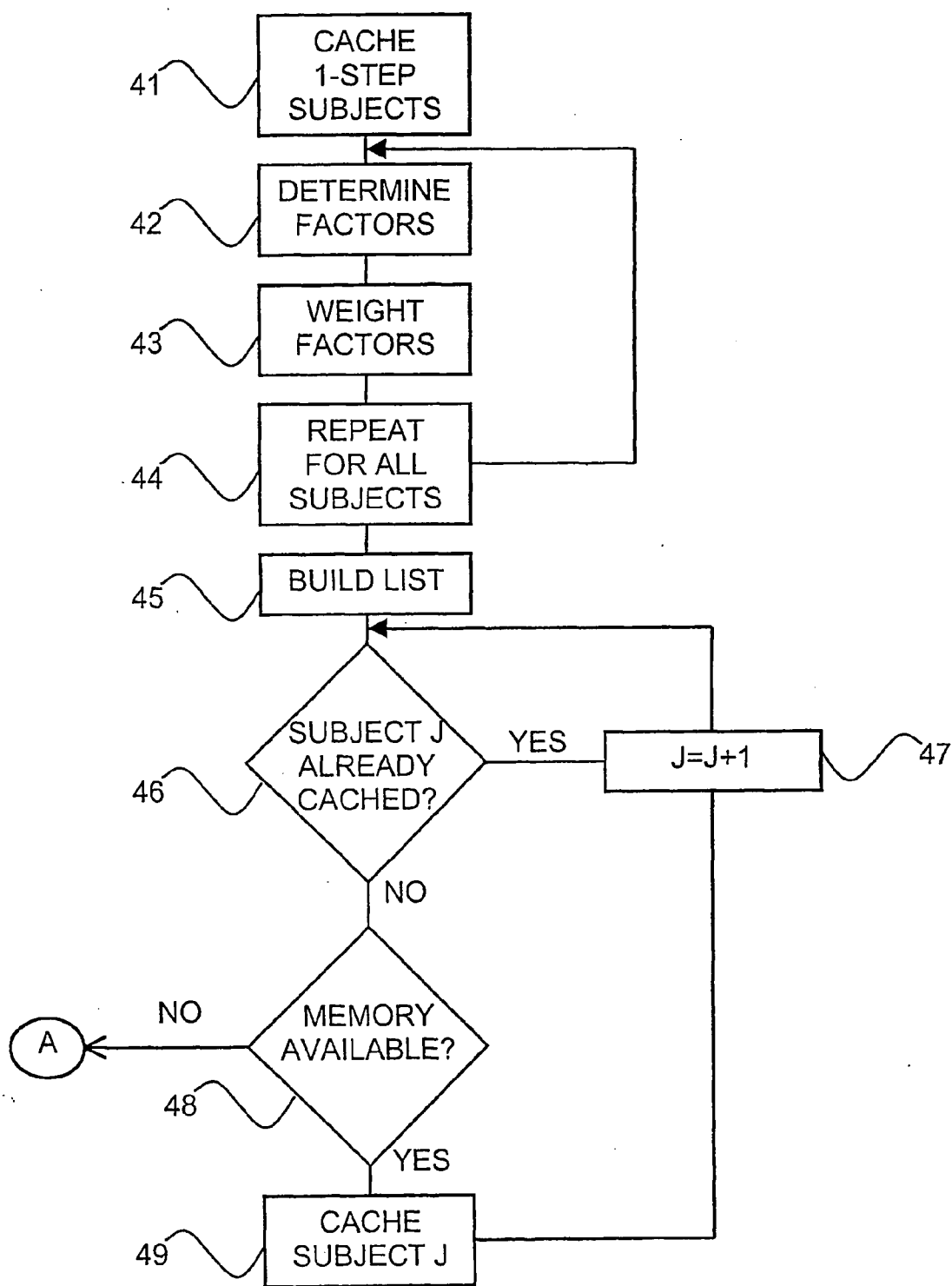


Fig 4

4/4

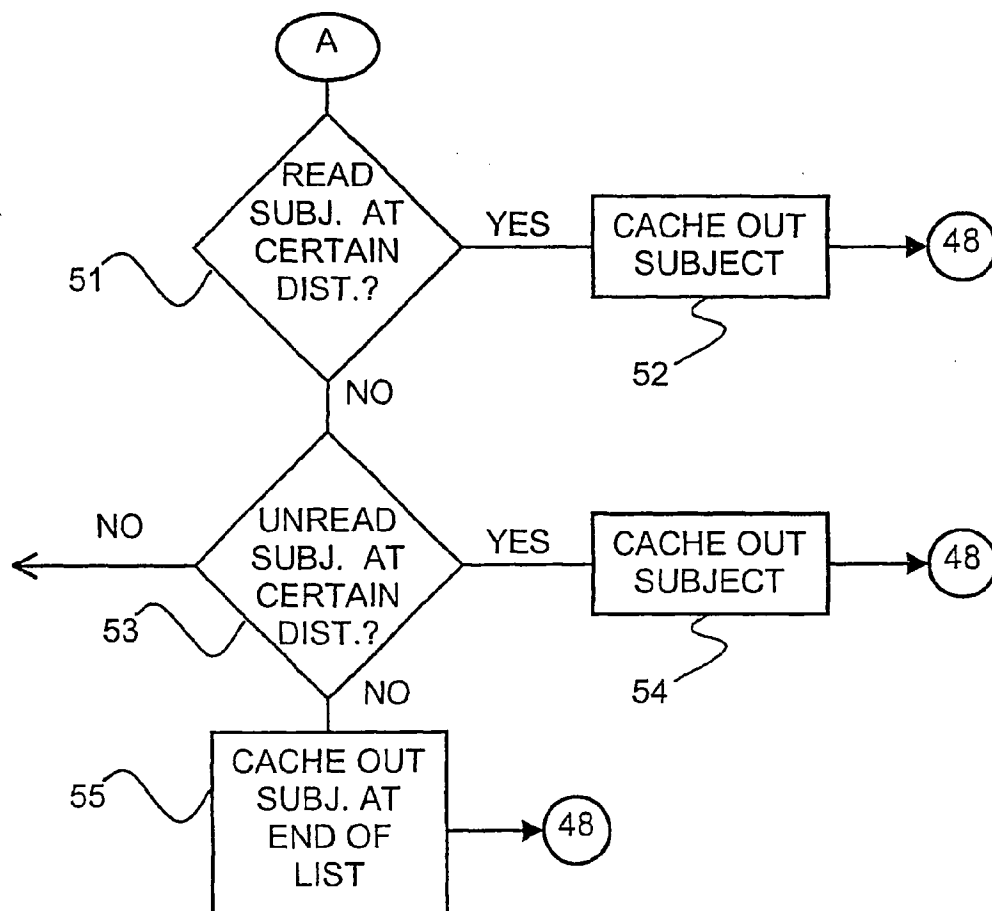


Fig 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/01935

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04N 7/173

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI DATA, EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5790935 A (PAYTON D.W.), 4 August 1998 (04.08.98), column 3, line 9 - line 32; column 4, line 55 - line 57; column 5, line 6 - line 19, column 6, line 1 - line 19; column 6 line 36 - line 50 --	1-10
A	"Spyglass Prism 3.1 Supports the latest Standards for Transmission of Content to Wireless Devices" [Online] 5 July 2000 (2000-07-05), pages 1-3, XP002160099 Retrieved from the Internet: <URL:www.opentv.com/ news/2000/070500b.html> Retrieved on 2001-02-12. See page 1, paragraph 2; page 2 paragraph 3 --	1-10

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/01935

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT
Information on patent family members

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